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Wuppertal Institut

Recommendations for an adequate policy package to support highly efficient and ultralow emission small-scale residential biomass combustion technologies in Europe

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Abstract

Small-scale residential biomass combustion for space heating and warm water production already holds a considerable share on overall energy production from biomass in Europe [1]. In the existing regulative framework of EU air quality and climate protection targets, an extended usage of renewable biomass heating without an increase of harmful emissions is urgently needed [2]. In this context, the FP7 project 'EU-UltraLowDust' (ULD) aimed at the demonstration of highly efficient and ultra-low emission small-scale biomass combustion technologies and the development of supporting policy recommendations [3].

New combustion technology operating at almost zero particulate matter (PM) emissions has been demonstrated, rivalling even the performance of state-of-the-art natural gas fuelled systems. In this context, the authors analysed EU policy options for a faster diffusion of these new innovative technologies. The analysis presented in this paper is based on results from an original impact assessment with special focus on energy efficiency and emission scenarios, including the potential effects of a broad deployment of the new ULD technologies as well as the early replacement of poor performing existing installations.

As the derived results show that major shares of energy consumption and emissions from residential biomass combustion in the EU are caused by old heating systems, specific policy measures for new and existing installations have been analysed. Following this, a recommended and harmonized policy package for new Small Combustion Installations (SCI) to be put on the market as well as for existing SCI in the stock has been developed, which will be presented in this paper. The basic policy package addresses new installations and consists of a two-step approach, aiming at enhancing the current and forthcoming policies addressing the SCI market in Europe. A complementary second policy package for existing installations aims specifically at the early replacement of SCI already installed in the stock, which are characterized by low efficiency and high emissions.

Introduction

Small-scale residential biomass combustion for space heating and warm water production already holds a considerable share on overall energy production from biomass in Europe [1]. With the "202020" goal of providing 20 % primary energy from renewable sources by 2020, the EU Directive "on the promotion of the use of energy from renewable sources" (2009/28/EC) expects also to increase sustainable solid biomass combustion significantly [4], which however requires additional efforts and incentives by the EU and the member states (MS).

Considering the existing regulative framework for achieving EU climate protection and air quality targets, an extended usage of efficient renewable biomass heating and a significant reduction of harmful emissions are needed at the same time. Especially particulate matter (PM) emissions have been identified as hazardous to health [2] and therefore, in the EU Directive "on ambient air quality and cleaner air for Europe" (2008/50/EC), a daily mean limit value of 50 µg/m^3 PM_{10} is defined for the protection of human health, which shall not be exceeded more than 35 times per calendar year [5]. However, even the most recent measurements show that this defined limit is still exceeded regularly in many areas all over Europe. Next to the transport sector, solid fuel combustion has been identified as one of the main sources for this ambient air pollution regarding PM, especially originating from poor performing out-dated residential stoves (direct heaters) and boilers (indirect heaters).

In this context, the FP7 project 'EU-UltraLowDust' (ULD) [3] aimed at the demonstration of highly efficient and ultra-low emission small-scale biomass combustion technologies for direct and indirect heaters as well as the development of supporting policy recommendations.

To reach these aims, a consortium had been formed, consisting of the manufacturers of the analysed key technologies as well as research institutions, which supported the industrial partners with their expertise. For wood pellet and wood chip combustion in indirect heaters a new highly efficient boiler technology ("UleWIN technology", whereby Ule is the abbreviation for 'Ultra low emission' and WIN is the abbreviation for the company name) operating at almost zero detectable PM (in terms of Total Suspended Particles, 'TSP'), OGC (Organic Gaseous Compounds) and CO (Carbon monoxide) emissions has been demonstrated, rivalling even the performance of state-of-the-art natural gas fuelled systems. Moreover, a new energy efficient wood log stove technology (APS technology, standing for "Active Power System") with optimized air staging and automated control system has been developed for direct heaters.

As the project also aimed to develop policy recommendations considering the results achieved by the new technologies, EU policy options for a faster diffusion of the most innovative technologies and their possible impacts have been assessed. Since major shares of the energy consumption and emissions from residential biomass combustion technologies in the EU are caused by out-dated old heating systems, specific measures for new products to be put on the market as well as for existing installations in the stock have been analysed and discussed with several relevant stakeholders in this area:

- Stringent Emission Limit Values (ELVs) for new installations, going beyond the level of current Best Available Technology (BAT), which could be e.g. part of a possible future revision of the EU Ecodesign regulations for Lot15 (solid fuel boilers) and Lot20 (local room heaters).

- Product labels, which allow a better visibility and promotion of the most innovative next generation technologies on the market.

- Ambitious new regulations with ELVs also for existing installations, as the emission reduction potential through replacement programs is very high.

- Incentive programs to foster a voluntary early replacement of inefficient existing installations with the most innovative new technology.

- Supplementary actions to further decrease the environmental impact of biomass small combustion installations in general (e.g. addressing user behaviour and fuel quality).

Based on this a recommended and harmonized policy package for new Small Combustion Installations (SCI) to be placed on the market as well as for existing SCI in the stock has been developed, which will be presented in this paper. The basic policy package addresses new installations and consists of a two-step approach, aiming at enhancing the current and forthcoming policies addressing the SCI market in Europe. A complementary second policy package part for existing installations aims at the early replacement of SCI already installed in the stock, which are characterized by low efficiency and high emissions.

As outlined above, there are strong arguments to increase small-scale renewable biomass solid fuel usage in the European heating market for greenhouse gas (GHG) emission reduction purposes and to reduce also health-relevant emissions at the same time through the market diffusion of significantly improved combustion systems such as the new technologies demonstrated in the ULD project. In order to show the urgency of an accelerated market and stock transformation by means of SCI specific policy instruments, this paper presents in its first part a technical efficiency and emission reduction potential analysis for Europe. For this purpose different scenarios have been assessed by means of a stock modelling approach. In the second part of the paper, the synergetic policy options and recommendations are comprehensively presented and discussed.

Analysis of the efficiency and emission reduction potential in Europe

During the ULD project an impact assessment was performed to assess different scenarios for solid fuel Small Combustion Installations in the EU market, paying detailed attention to energy consumption and emissions for following product categories: logwood boilers, logwood stoves, wood pellet boilers and wood chip boilers. Together, these product categories cover the most significant part of the solid fuel SCI market in Europe in terms of energy consumption. According to the Ecodesign preparatory study for Lot15 and 20 these categories combined account for 63 % of the overall solid fuel consumption in the EU27 (logwood boilers: 45 %, logwood stoves: 8 %, wood pellet boilers: 8 % and wood chip boilers: 2 %). Furthermore these product groups are also characterized by significant additional technical efficiency and emission reduction potentials (e.g. in contrast to already better performing pellet stoves, which are a relatively new and advanced technology using also high-quality standardized fuels).

The performed impact assessment considered the final performance parameters achieved by the demonstrated new ULD technologies as well as scenarios to show the improvement potentials, which should be addressed by adequate policies and measures:

- In the “Business as Usual Scenario” (BAU) only Base Case products (typical products on the market) will be purchased in the future. This is the baseline reference scenario.
- In the “Ecodesign” scenario, as of 2022, every new SCI purchased on the EU market fulfils the requirements of the Lot15/20 Ecodesign implementing measures as adopted by the Ecodesign Regulatory Committee in October 2014 [6][7]. Therefore, beginning in 2022, 100 % market share for products complying Ecodesign is assumed.
- In the ULD scenario, as of 2022, every new product will be an ULD product. Assumption: ULD technology has 100 % market share as of 2022, in order to show the additional technical improvement potential of the new technologies.

For the purposes of this paper the focus is lead on energy efficiency and PM (in terms of Total Suspended Particles, ‘TSP’) as the most health relevant category of emissions from solid fuel SCI.

The following Figure 1 shows the development of the annual solid fuel consumption for all ULD product groups (direct and indirect heaters) combined. Due to the assumed general reduction effect of the EPBD (Energy Performance of Buildings Directive, 2010/31/EU) [8] on the heat demand of the building stock in Europe and the autonomous replacement of old (and typically inefficient) end-of-life products, the overall energy consumption of SCI can be reduced after reaching a peak of 1,927 PJ/year in 2024, although the stock of installed SCI is expected to double until 2050 (absolute decoupling). While a general decoupling can already be reached in the Business As Usual (BAU) scenario, Ecodesign with Minimum Energy Performance Standards (MEPS) and especially the innovative ULD technology would allow to achieve even larger savings.

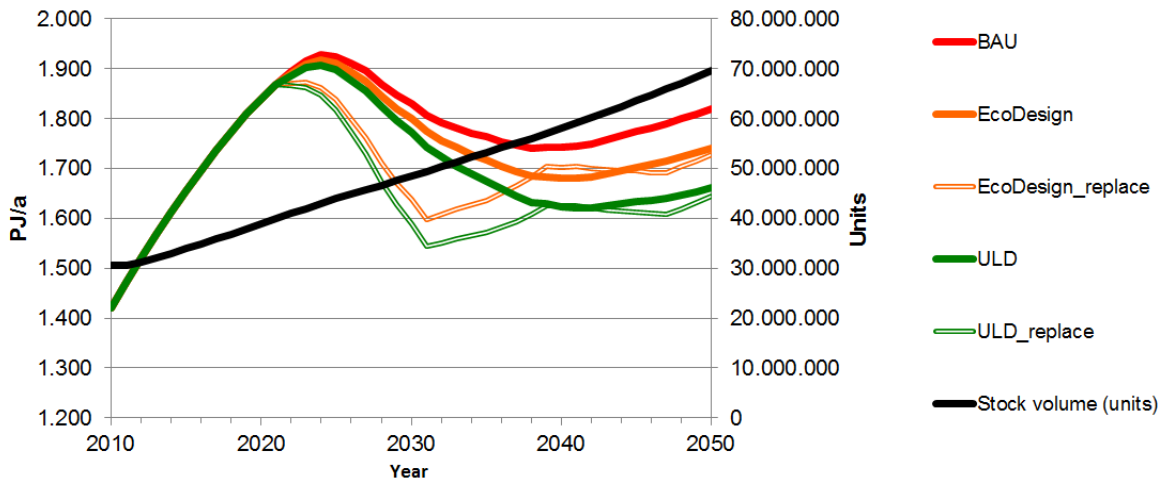

Figure 1: Development of solid fuel consumption in the different scenarios (EU27)

Source: Own calculations by the authors based on Ecodesign preparatory study and ULD project

However, in all scenarios addressing the market (and therefore solely new products) the full efficiency improvements will be reached only after several years, since solid fuel combustion installations are characterized by a long technical lifetime (typically about 20 years for boilers and more than 25 years for stoves). Thus, for the ULD and Ecodesign scenarios, an additional early replacement option has been considered respectively (see *_replace* scenarios): As of 2022, any existing "old" SCI in the stock with 10 years remaining lifetime will be replaced by a new one, which complies with the regulatory performance requirements for new products of the respective scenario in the year of purchase. Thereby, the *_replace* sub-scenarios show that addressing existing SCIs in the stock would especially allow harnessing the significant efficiency and emission reduction potentials much earlier. Based on the same general assumptions, the following Figure 2 shows also the TSP emission reduction potentials for all ULD relevant SCI product groups combined. Due to the general reduction effect of the EPBD and the autonomous replacement of old end-of-life products with typically high emissions, the TSP emissions in the BAU scenario can be hold steady close to 110,000 t/year in the next decades, although the stock of installed SCI is expected to double in the same period (relative decoupling).

The implementation of Ecodesign regulation for Lot15 and 20 with specific emission limit values (ELVs) has the potential to reduce also other environmental impacts than energy consumption of solid fuel SCI. Accordingly, in the Ecodesign scenarios an absolute decoupling of the total TSP emissions and the number of installed heating systems is possible. This underlines that the possibility to include relevant non-energy aspects in Ecodesign implementation measures is highly beneficial to enable major co-benefits of energy efficiency. Additionally, the calculations also show that Ecodesign measures with ELVs should be implemented as soon as possible, as any delay would mean the loss of several thousand tons of possible PM (TSP) emission savings per year.

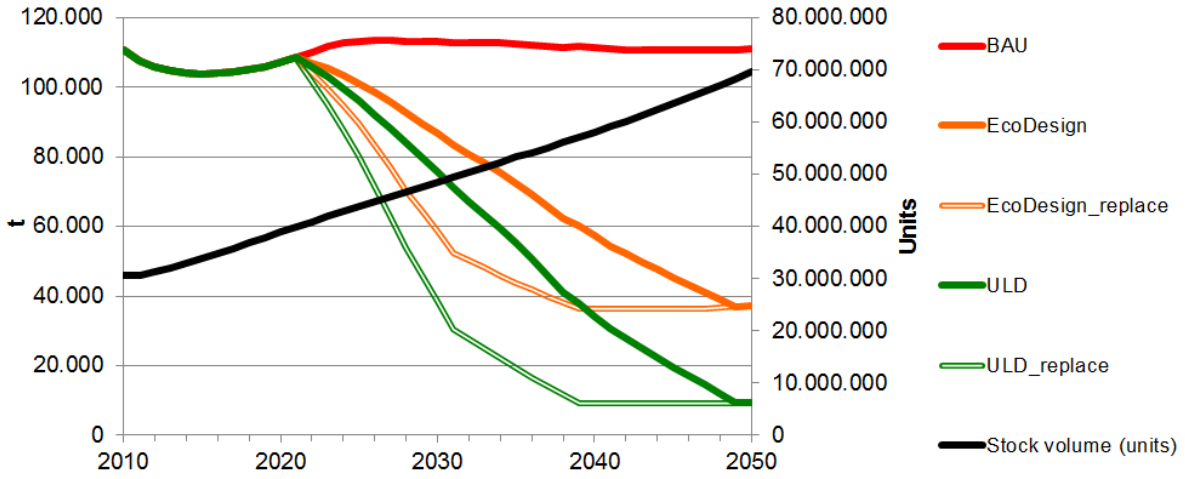

Figure 2: Development of PM (TSP) emissions in the different scenarios (EU27)

Source: Own calculations by the authors based on Ecodesign preparatory study and ULD project

The demonstrated new ULD technologies would even have the technical potential to reduce the overall PM (TSP) emissions to a much greater extent down to 9,469 t/year by 2050 (-91 % compared to BAU and -74 % compared to Ecodesign in the same year). Thereby, the *_replace* sub-scenarios show strong evidences that especially the early replacement of inefficient existing SCI in the stock with high emissions is playing a key role for a significantly accelerated reduction of overall emissions and related negative health effects. Based on results of the performed quantitative analysis, it can be clearly stated that without further and significantly accelerated technical improvements as well as adequate new policy measures for logwood stoves, wood log-, wood pellet- and wood chip boilers the full efficiency and emission reduction potential in the EU cannot be achieved. Without encouraged policy intervention, long-term negative lock-in effects as consequence of prolonged sale and usage of inefficient SCI with elevated emission levels would delay for decades the achievable economic, ecologic and social (health) benefits of innovative new technologies and therefore also the full realisation of the important GHG emission reduction potential of renewable biomass usage.

Discussion: Policy options and recommendations

Why further policies are required

Currently, there are already efforts by the EU and Member States to implement policies and measures for SCI with the intention to increase energy efficiency and to address air quality (see Figure 3). As shown by the scenario calculations, the implementation of Lot15/Lot20 Ecodesign measures with requirements for higher energy efficiency and much lower specific emissions for SCI [6][7] has the capability to improve the situation already to a relevant extent. Thereby, the performed calculations confirmed in particular the importance and effectiveness of EU Ecodesign as instrument to increase energy efficiency with the ability to trigger highly relevant co-benefits at the same time. From an economical perspective, the investment costs for products fulfilling Ecodesign requirements are often also comparable to Base Case products, so that end-users could even realise a cost advantage by energy cost savings at the same time as a result of more fuel-efficient products complying with Ecodesign requirements.

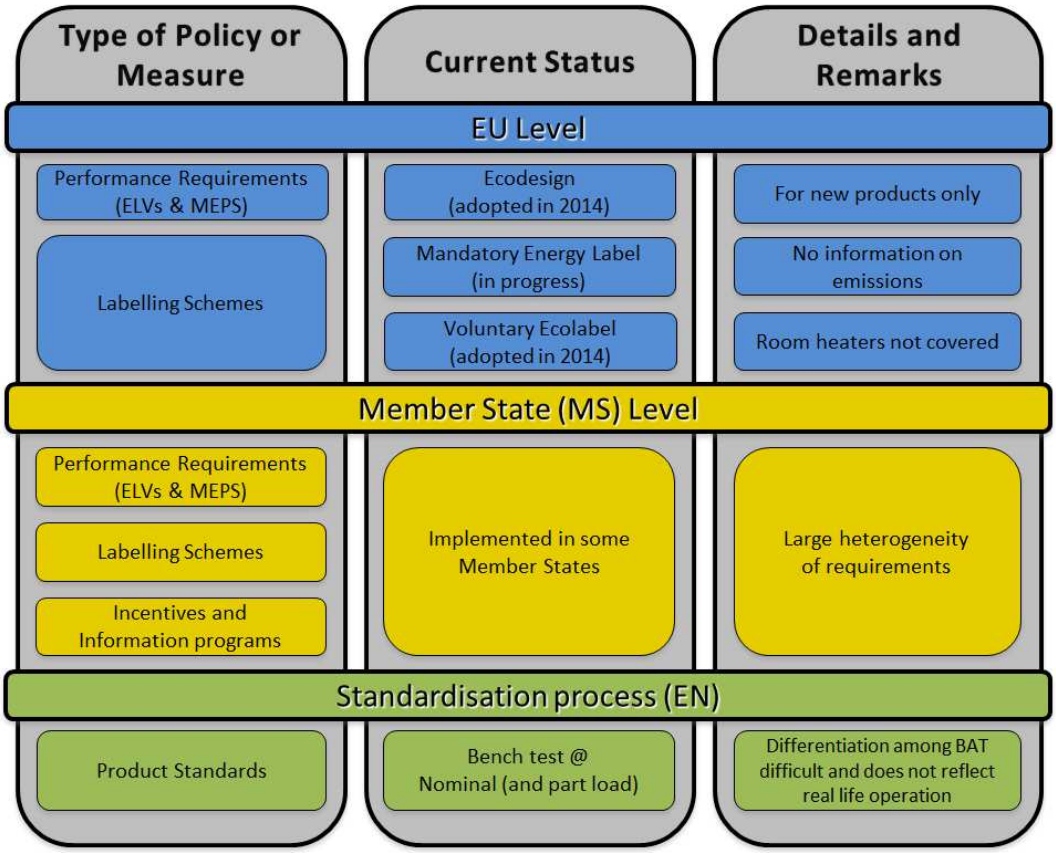

Figure 3: Current status of the policy package for new biomass solid fuel SCI (EU28)

Source: Own illustration by the authors based on ULD project

Beyond Ecodesign, the technologies demonstrated in the ULD project would have the potential to reach even larger energy and emission savings in a much shorter time period. However, all new systems developed in the ULD project are still more expensive than comparable Ecodesign or Base Case products. This is related to the typical higher initial investment costs of new technologies, which are not fully compensated by lower operation costs, as the fuel efficiency aspect alone can already be pushed near to the upper technical limit by Ecodesign or BAT products. In addition, there are currently no adequate financial rewarding schemes for the achievable emission reductions by the ULD technologies. Although the problem of higher initial investment costs could be overcome gradually by economies of scale, this is another reason, why specific policies and measures will be necessary to

support a much faster and deeper market diffusion of the most advanced technologies in order realise the full technical energy efficiency and emission reduction potential.

For this purpose and in the light of the results achieved within the ULD project, the developed complementary policy packages for new SCI to be placed on the market as well as for existing SCI in the stock are subsequently described and discussed in detail.

Recommended basic policy package for new SCI

General policy package approach

In order to overcome effectively the existing major market barriers and obstacles, transformation towards better performing technologies has to be initiated by "push" measures with binding minimum performance standards like EU Ecodesign with mandatory requirements for efficiency (Minimum Energy Performance Standards) and for emissions (Emission Limit Values). In accordance with EU Directive 2009/28/EC, additional "pull" measures like labelling schemes (e.g. EU Energy- and Ecolabel), financial incentives or Green Public Procurement as well as information and training programs for users and installers (including certification) are also crucial to support a much faster and deeper market transformation. As experiences show, well-coordinated bundles of such policy instruments can form a synergetic and much more effective "policy package" [9].

Two steps of improvement

Although some EU policy instruments have been implemented or are prepared for final implementation (Figure 3), there is still no holistic policy package approach for SCI on EU-level yet. Additionally, some of the instruments, like the forthcoming EU Energy Labelling, cover only energy efficiency and will therefore not be sufficient to harness also important co-benefits (e.g. reduction of SCI related emissions) at the same time. In this context a two-step policy evolution approach for new SCI is recommended in order to create a comprehensive policy package addressing the market of SCI on EU-level more effectively (see Figure 4 below):

- **Step 1:** Implementation of further developed "pull measures", which are based on existing bench type testing methods for SCI products. This may in particular include the EU Ecolabel, a revised EU Energy Label with emission information directly on the label as well as EN product standards including new product performance classes.

- **Step 2:** Major revision or development of new EN standards, considering the latest technological progress and more realistic operation testing conditions for efficiency and emissions. At the end of Step 2, the entire SCI policy package will have to be updated according to the new EN standards.

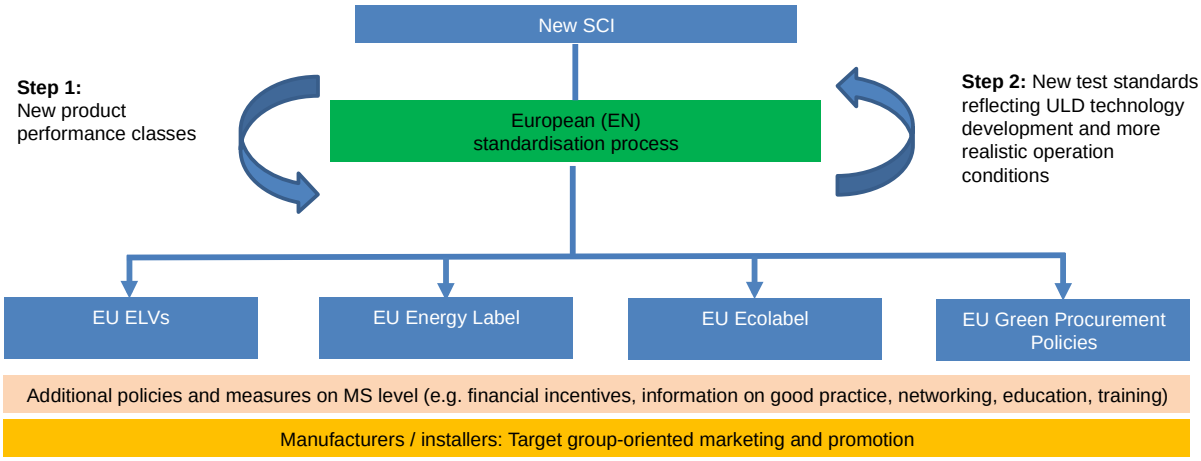

Figure 4: Recommended basic policy package for new SCI: Two-step approach

Source: Own illustration by the authors based on ULD project

The EU policy package for new SCI should be furthermore complemented by target group-oriented marketing and promotion by manufacturers and installers as well as adequate Member States policies (e.g. financial incentives for BAT or better, information on good practice, networking with energy auditors, installers and chimney sweepers, education, training/certification and public procurement rules).

Step 1: Improving product information for new SCI in the EU

MEPS and ELVs addressing the market access for new SCI in the EU

The cornerstone of any policy package with the aim to improve effectively the performance of appliances on the market is the implementation of mandatory minimum performance standards regulating the EU market access for new products. In the case of biomass solid fuel heating systems, MEPS (for energy efficiency) as well as emission limit values (ELVs) have to be regulated. Thereby, the EU Ecodesign process [6][7] already includes such “push measures” for new biomass solid fuel appliances. However, the demonstrated ULD technology would already provide a reference base for adjusting even more stringent requirements in a possible future review of the Ecodesign implementing measures.

Therefore, until stricter mandatory product performance criteria would be possible, improved product information (e.g. by labelling schemes, etc.) remains essential, as it will enable consumers to make more conscious purchase decisions towards the most innovative products. Additionally, improved EU product information could also provide the foundation e.g. for more ambitious emission-based policy packages by Member States as well as for target group-oriented marketing and promotion activities by manufacturers and installers.

EU Energy Labelling

Besides Ecodesign, the mandatory EU Energy Labelling is another powerful EU policy instrument to support an accelerated market transformation towards more energy efficient products on the European market. For biomass solid fuel SCI, the market transformation has to be supported towards emission reduction at the same time. However, the forthcoming current EU Energy Labelling approach with focus only on energy efficiency [6][7], will not be sufficient to provide a distinction between current BAT products and ULD technologies regarding their co-benefits, because for these high-end products there is no more a systematic direct correlation between better energy efficiency and much lower emissions. For example, the very best BAT boilers (with condensing technology) can achieve already the upper technical limit for energy efficiency, but not the same low emission levels as ULD products at the same time. In order to make this difference prominently visible to the end-user and to reflect adequately these additional co-benefits, dedicated new information requirements on the product label itself are needed. For this purpose, it is recommended to show on a future mandatory EU Energy label also easily comprehensible information regarding PM emissions in order to address at least the most health relevant emission category.

EU Ecolabelling

The EU Ecolabel - the voluntary environment endorsement label of the European Commission - can be an effective instrument for an additional promotion and faster market diffusion of very innovative technologies. “Commission Decision 2014/314/EU establishing the criteria for the award of the EU Ecolabel for water-based heaters”, covering also solid fuel boilers, has been adopted on 28 May 2014. After publication in the Official Journal of the EU in June 2014 it entered into force immediately and is subsequently applicable for the next 4 years [12]. It includes ambitious efficiency and emission requirements for biomass SCI and might already promote current BAT after the registration of the first products. Nevertheless, compared to the performance level of the new ULD technology, there would even remain a potential for more demanding requirements in a next label version in order to support the most innovative technology.

Revision of current product standards

In order to further promote ULD technologies, EU research programs for new or further revised product and test standards should be supported, including the respective tenders for CEN for an accelerated implementation of the new standards. Currently, for solid fuel boilers (indirect heaters) the highest product performance class defined in the applicable EN standard does not allow to make a

distinction between good, very good and the best technologies already on the market. For example, the majority of wood pellet boilers put on the market in 2013 already achieved the highest class requirements. Therefore, the introduction of new classes should be considered, as especially a class only achievable by the most advanced appliances would allow manufacturers to claim a distinct level of product performance based on official and generally accepted technical documents. This could encourage manufacturers to foster innovation even before other (mandatory) requirements will come into force or will be reviewed. For solid fuel local room heaters (direct heaters), the current standards do not include any performance classes at all, which should be also addressed in future standards or revisions.

Basic financial incentives addressing new SCI on the market

Such as many new approaches, ULD technologies face initially a financial barrier due to the higher upfront investment costs compared to current BAT solid biomass and especially oil and gas heating technologies on the EU market. Therefore, financial incentives can be an important argument for customers to opt for innovative, but initially more expensive ultra low emission biomass technology instead of other products fulfilling just the required minimum performance criteria. However, tax rebates, subsidies, or other financial incentives to support products directly can currently not be implemented or prescribed by the EU, as such measures are only possible on Member State level.

Also other current EU instruments like the Structural Funds of the EC (DG REGIO) cannot be used for such specific purposes, because no direct support of end-users is allowed. The European Investment Bank (EIB) is considering programs for sustainability measures in the building stock (e.g. social housing or on district level), but only with a holistic approach and not for specific building technologies like heating systems. Consequently, existing examples for specific financial incentives in the context of SCI can only be found on EU Member State level (e.g. BAFA scheme in Germany, CIDD/crédit d'impôt développement durable in France or the Voivodeship Fund for Environment Protection in Poland). Besides incentive programs by EU Member States, there are also numerous other existing incentives for biomass heating technologies implemented on regional or municipal level across Europe.

Thus, it is recommended to take improved and synergetic multi-level governance action on EU, Member State and regional level (including e.g. INEA, Covenant of Mayors, etc.) to revise existing financial incentive schemes and to implement new ones, respectively based on the improved product information proposed in Step 1 for new SCI. Depending on the economic situation of the MS, at first glance the implementation of such incentives might seem to be challenging, but many other possible positive long-term effects (such as fostering regional investments, local creation of new ‘green’ jobs in the forestry sector or in manufacturing industry/SME, related fuel cost savings, increased security of energy supply as well as reduced air-quality related negative health impacts, etc.) need also to be taken into account. By this means, the whole society will benefit from reducing energy consumption and emissions, in particular in terms of lower energy and health costs, but e.g. also due to avoided possible Ambient Air Quality Directive related monetary penalties. Therefore public authorities on all levels should be highly interested in allocating money for financial incentives programmes for innovative new technologies. All potential new incentive schemes should thereby be always complemented by information on good practice, networking with energy auditors, installers as well as education, training and public procurement rules on Member State and local/regional level.

Promotion and marketing activities by manufacturers and installers

Finally, it should not be underestimated that manufacturers and installers and their associations have an important role in promoting especially highly efficient technology with ultra low emissions and to show the additional co-benefits of such products. For this purpose, they can perform target group-oriented marketing campaigns to highlight the general advantages, the environmental benefits as well as other added value aspects of the innovative technology.

Step 2: Addressing real-life product performance of new SCI on the market

Comprehensive revision of product and test standards

- Efficiency and especially emissions of heating systems are in reality different than measured according to current product type testing approaches, because operation patterns under real-life conditions are deviating from synthetic benchmarks. In particular, the actual performance depends also on the entire heating system as well as user behaviour. Therefore major revisions of product and test standards are recommended, in order to include much more realistic test requirements.

Update of the entire specific policy package for new SCI

As soon as the relevant product and test standards have been revised, all existing as well as new policies and measures of the policy package addressing new SCI will have to be updated accordingly for consistency. As the new product and test standards could focus in particular on the most health-relevant emissions like the PM_{10} or $PM_{2.5}$ particle fractions, also a more specific policy development would be possible afterwards. Based on the policy instruments suggested in Step 2 for new installations, Figure 5 presents an overview of the current specific EU policy package for new SCI and the recommended policy evolution.

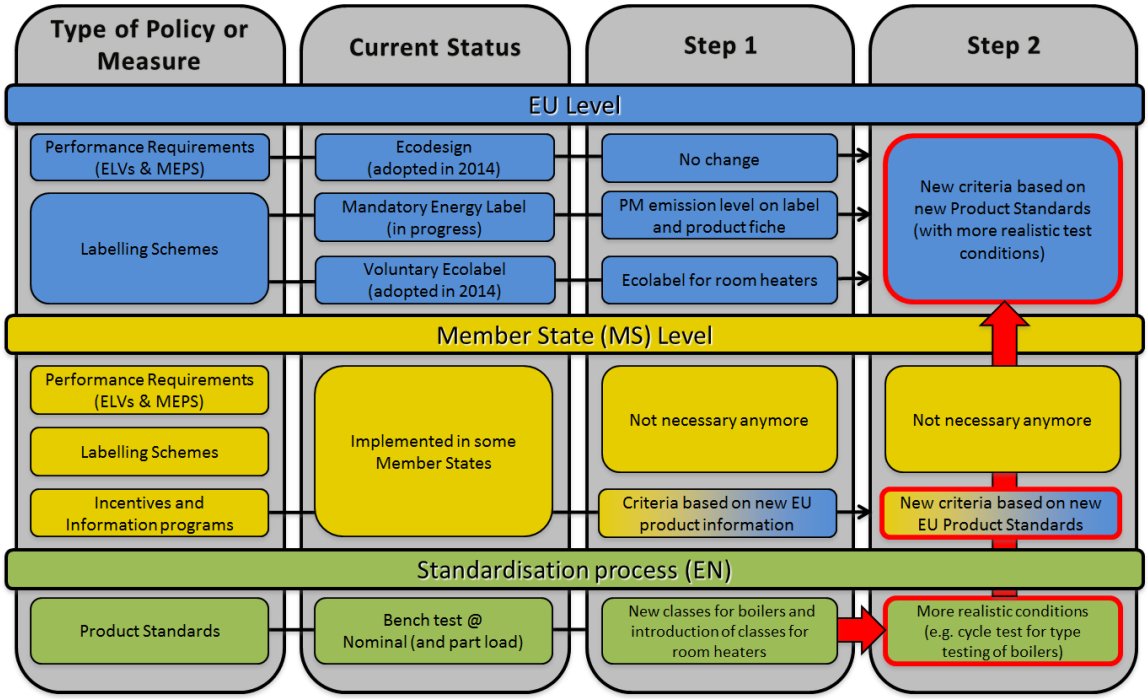

Figure 5: Recommended evolution of the policy package for new solid biomass SCI: Step 2

Source: Own illustration by the authors based on ULD project

Complementary recommended policy package for existing SCI

General policy package approach

The performed impact assessment scenario calculations highlighted the urgent need to address not only the market and therefore solely new products, but especially also the existing stock of old and poorly performing appliances. Thus, it is recommended to introduce a complementary policy package specifically for existing SCI (to be applied in synergy with the recommended measures for new SCI), which will accelerate significantly the early exchange of existing out-dated installations compared to the autonomous replacement process induced solely by the technical product lifetime.

This complementary policy package for existing SCI in the stock should include:

(1) Regulation

Minimum performance requirements addressing specifically existing SCI in the stock

Analyses of different international voluntary change-out initiatives for solid fuel heating system have principally confirmed their general effectiveness and benefits regarding efficiency gains and emission reductions [2]. However it was also revealed that the long average service life of such appliances - once installed – is a relevant limitation for voluntary approaches.

In order to tackle this limitation the EU or Member States shall implement – synergetic to the before described measures for new SCI - also specific additional mandatory requirements for existing SCI, which ensure an effective accelerated exchange of old and poor performing existing installations with much better performing new biomass solid fuel systems. In any case, if regulatory restrictions do not yet allow such requirements directly on EU-level, the EU should at least encourage the implementation on Member State level.

For such future regulations, also experiences of the implementation of the German 1. BimSchV [13] emission regulation (with its ambitious 2nd tier coming into force in 2015) should be taken into account, which is so far the only national policy of this kind in the EU:

- For solid fuel indirect heaters (boilers): Introduction of operation performance requirements with special focus also on PM emissions as well as periodical on-site inspections, which are e.g. performed by chimney sweepers or other responsible authorities.

- For solid fuel direct heaters (local room heaters): The regulation shall be based on a type testing approach, but according to new or revised EN standards as described in Step 1 for new SCI.

- The regulations shall include general mandatory replacement requirements for existing installations not complying with the new standards.

Thereby regulation approaches shall be preferred, with the target of an overall performance improvement of the whole stock of installed biomass solid fuel heating systems by means of ultra low emission biomass technology so that the general or temporary banning of biomass solid fuel usage (e.g. during periods with PM values exceeding the limits of EU Directive 2008/50/EC) can be avoided to ensure security of energy and heating supply.

Although the implementation of such regulation is challenging in certain aspects (on-site inspections need e.g. adequate training of the chimney sweepers as well as special equipment), only such mandatory policies can ensure that inefficient appliances with high emissions will be actually removed much earlier from the stock and would be consequently replaced in any case by better performing products, as consequence of minimum requirements in the basic policy package for new SCI addressing the market [2]. In this context, it is also recommended to improve the general usage of adequate market and stock surveillance as well as the usage of respective product databases on EU and Member State level in order to have always access to up-to-date and reliable data for more specific policies [14]. Thereby, experiences from existing databases (such as e.g. the German HKI compliance database for SCI, http://cert.hki-online.de/) should be taken into account.

Fuel quality

As fuel quality has been identified as an essential influencing factor for the real-life performance of solid fuel SCI, it is recommended to include also this parameter in specific regulatory measures. For this purpose, the quality of the fuel should be especially controlled and regulated at the point of sale, what is mainly of relevance for fuels, which are sold on the market in large quantities, e.g. by bulk wholesalers. In this context, a reliable certification system for the suppliers and a control mechanism for the fuel stock would be required. In case of specific biomass solid fuels, where a significant share is typically originating from smaller own resources of the SCI users (e.g. wood logs, saw dust, wood chips from private forest estates or related timber industries), especially good practice rules should be applied. Considering this, all measures to exclude fuels of inadequate quality would have immediate and measureable positive effects on product performance and the environment.

(2) Cumulative financial incentives addressing existing SCI in the stock

Besides the long service life of installed solid fuel heating systems, analyses of different international change-out initiatives have revealed the costs of the best technologies as another relevant limitation of any voluntary exchange approach [2]. In order to tackle this barrier and to address remaining SCI in the stock, which comply with mandatory performance requirements for existing installations as described in (1), but whose performance is clearly below BAT level of the market, additional financial incentives shall be implemented as "pull" mechanism to support a voluntary early replacement. Thereby, the incentive for early replacement shall be cumulative to basic incentives granted for new products (see section "recommended basic policy package for new SCI"), supporting in particular the purchase of the most innovative new products with significantly better performance levels than Ecodesign / MEPS minimum requirements as substitute (Figure 6).

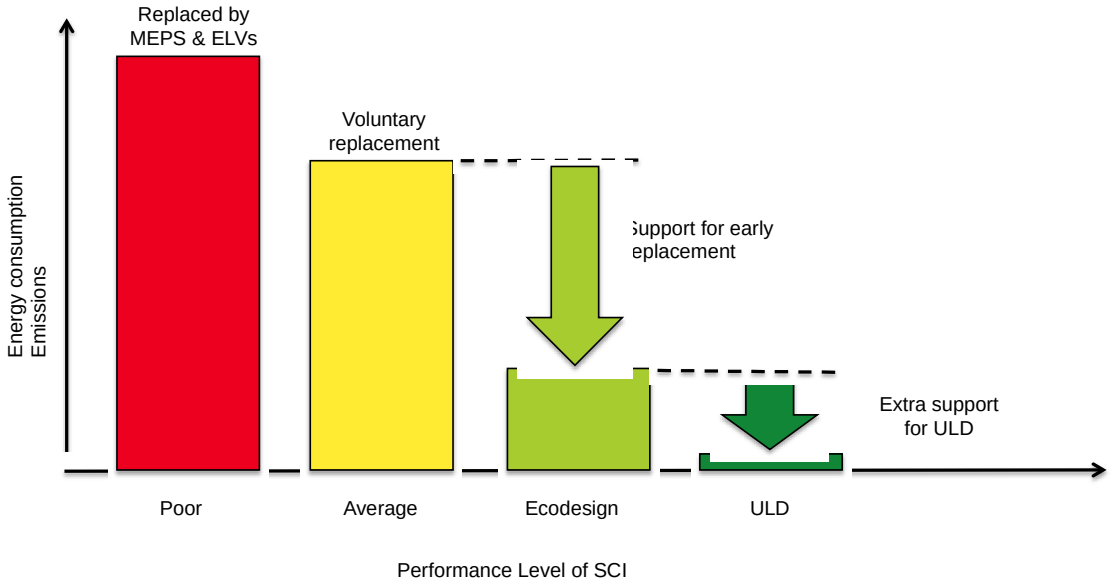

Figure 6: Cumulative financial incentives for early replacement with ULD as substitute

Source: Own illustration by the authors based on ULD project

However, also financial incentives for early replacement can currently not be implemented or prescribed directly by the EU. Consequently, examples for such complementary financial incentive schemes to replace old SCI by much better performing new ones can only be found on Member States level (e.g. Incentive for replacement of old installations in Austria, CIDD in France, Voivodeship Fund for Environmental Protection in Poland).

(3) Information, education, training, networking and promotion

To complement the measures described in (1) and (2) for existing SCI in the stock, it is recommended that chimney sweepers (or other responsible authorities) also check the entire heating installation and the quality of fuel on a regular basis. Furthermore, for biomass solid fuel SCI, improper operation is another relevant parameter influencing negatively the real-life performance. For this purpose, extensive good practice information programs - beyond printed information at the point of sale - should be provided to the owners and operators of all installed systems. Thereby, training could be also realized during the regular and official chimney sweeper visits in combination with the provision of advanced information brochures like e.g. the "Low emission operation manual for chimney stoves" developed in the ERA-NET "FutureBioTec" project [15]. Again, manufacturers and installers and their associations have also a strong role in promoting the exchange of inefficient existing SCI in the stock. They could perform target group-oriented marketing campaigns (e.g. in the context of regular maintenance procedures) to highlight the need for improvements and the innovative character, the environmental co-benefits as well as further advantages of exchanging existing old appliances with highly efficient new products.

Summary and Outlook

This paper presented results from impact assessment scenario calculations for technical energy efficiency and emission reduction potentials as well as respective policy options and recommendations to support highly efficient and ultra low emission small-scale residential biomass heating systems in Europe with the target to harness the significant improvement potentials as far and as soon as possible.

For this purpose, the recommended basic policy package for new SCI to be put on the EU market consists of a two-step approach and aims at supplementing the current and already forthcoming policies addressing new SCI in Europe. Following stakeholder feedback, the realization of the recommended Step 1 for new SCI should be possible in short- to medium term, e.g. following a respective EU Ecodesign and labelling implementation. In this context, the European standardisation processes might require more time than other parts of Step 1, as new testing methods have to be agreed and approved especially with respect to emissions. The same is also valid in Step 2 in the new SCI policy package, where the development of essentially new and more realistic testing methods (considering real-life operation) as well as the subsequent adaptation of all relevant regulations could require more time. Therefore, based on the necessary research and regulatory process, Step 2 should be envisaged according to stakeholder feedback in a medium to long-term perspective.

The second recommended and complementary policy package for existing SCI is intended to support in particular the early substitution of poorly performing existing solid fuel SCI in the stock with significantly improved new heating systems, as the implementation of ambitious replacement programs is the most promising approach to achieve energy efficiency improvements as well as large and rapid emission reductions at the same time [3]. Thereby reliable databases for new products would be very helpful for consumers and - in combination with registers of already installed SCI - an essential precondition for policy makers to develop replacement approaches [14]. As the EU can currently only encourage Member States to implement such concrete measures due to regulatory restrictions, a better harmonisation or even completely new and more holistic policy instruments on European Level would be needed.

Finally, in the context of both closely related policy package parts for new and existing SCI, two instruments are considered as most important by involved stakeholders: Mandatory performance ("Push") requirements to address energy efficiency and emissions of heating appliances directly and effectively as well as financial incentives to foster ("Pull") a much faster market and stock transformation. However, due to the existence of regulatory restrictions hindering currently the implementation of certain instruments on EU-level, in both SCI policy packages further and advanced information, promotion, networking, education and training/certification programs remain also essential in order to influence buying decisions of consumers and to reduce emissions in real-life operation by addressing user behaviour as well as the quality of fuels.

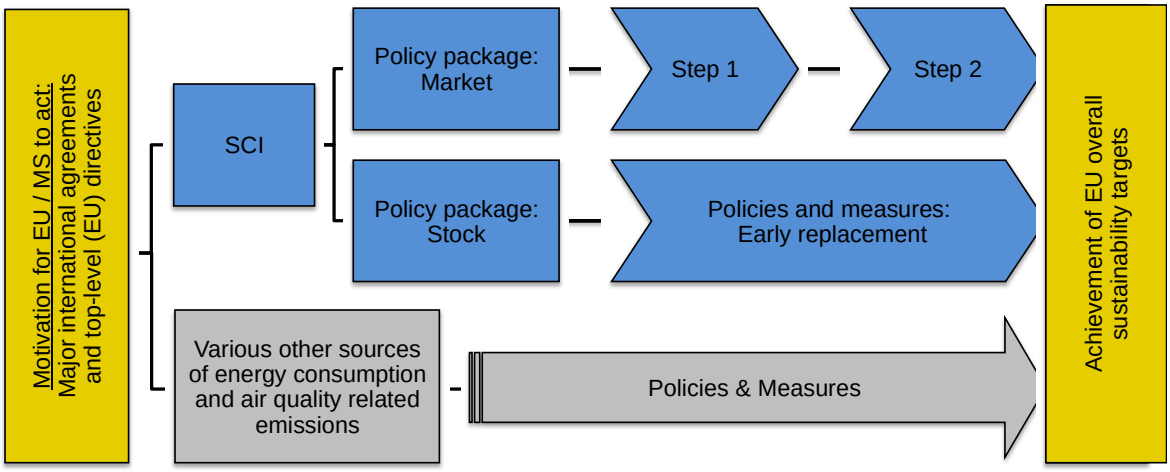

Figure 7: Context of the EU-UltraLowDust policy packages for SCI

Source: Own illustration by the authors based on ULD project

Taking into account the policy recommendations developed in the ULD project and discussions with several national / EU experts and authorities for solid fuel SCI as well as industry representatives, it can be stated that the implementation of the proposed policy packages is considered as difficult in certain aspects, but yet feasible. Substantial resources would be required but e.g. the EU multiannual financial framework, Horizon2020 or INEA/CEF may provide scientific and financial starting points. Based on this, incentives as well as cohesion in building codes will further support innovative technologies. EU Structural Funds can be used e.g. to address major regional energy or air quality issues and also to support the new Member States, where economic and social aspects have to be taken specifically into account.

Depending on possible tight economic situations in some MS, at first glance the implementation of ambitious measures might seem to be challenging, but many possible positive long-term effects (such as fostering EU-wide regional innovation and investments, local creation of new jobs, related fuel cost savings, increased security of energy supply as well as reduced air-quality related health costs, etc.) need also to be taken seriously into account. Especially in this context, it has to be stressed again that in most parts of Europe solid biomass is also the cheapest and most easily available type of fuel for heating purposes and it is therefore the basis for a very secure and economical type of heating systems. With this in mind, the ULD project demonstrated very promising technologies with high efficiencies and ultra-low emissions for boilers and stoves, which show the enormous general improvement potentials of an encouraged sustainable solid biomass heating strategy in Europe. In combination with adequate policy packages such innovative technology can also provide major co-benefits and contributions to achieve the declared EU-wide overall sustainability targets (Figure 7).

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